

Solar and Meteorological monitoring at Newcastle, Australia

New site proposal

Dr Benjamin Duck
Research Scientist

Kenrick Anderson
Experimental Scientist

Dr Chris Fell
Team Leader

Dr Greg Wilson
Group Leader

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ENERGY
www.csiro.au



What is CSIRO?

- CSIRO is Australia's national scientific research organisation

5319
talented staff

\$1billion+
budget

Working
with over
2800+
industry
partners

55
sites across
Australia

Top 1%
of global
research
agencies

Each year
6 CSIRO
technologies
contribute
\$5 billion to
the economy

CSIRO business units and focus areas



Agriculture



Energy



Food and Nutrition



Health and Biosecurity



Land and Water



Manufacturing



Mineral Resources



Oceans and Atmosphere



Astronomy and
Space Science



Australian Animal
Health Laboratory



Data61



Marine National Facility



National Computing
Infrastructure



National Research
Collections of Australia

Newcastle – National Solar Energy Centre

Advanced Solar Technologies

Concentrated Solar Thermal Central Receiver Facility

CSIRO Energy Centre



Photovoltaic Outdoor Research Facility (PVORF)

Photovoltaic Performance Laboratory (PVPL)



Renewable/Stored Energy Integration Facility



National Solar Energy Centre (NSEC)



National HVAC Performance Test Facility



PV Fab Lab Next Generation Photovoltaics

Our team



Benjamin Duck

Dr Benjamin Duck
Research Scientist
Station scientist

10 years experience in PV. 4 years experience in outdoor solar measurements.

Solar Photovoltaics, Optics, Femtosecond spectroscopy



Chris Fell

Dr Chris Fell
Team Leader:
Photovoltaic
Performance Laboratory

Over 20 years research experience.

Solar Photovoltaics, Solar Energy, Optics, Applied Physics



Kenrick Anderson

Mr Kenrick Anderson

Experimental Scientist
Station Deputy

5 years experience in outdoor solar measurements.



Greg Wilson

Dr Greg Wilson

Group Leader : Solar
Energy Systems Group

16 years research experience.

Solar energy, photovoltaics, energy storage, photochemistry

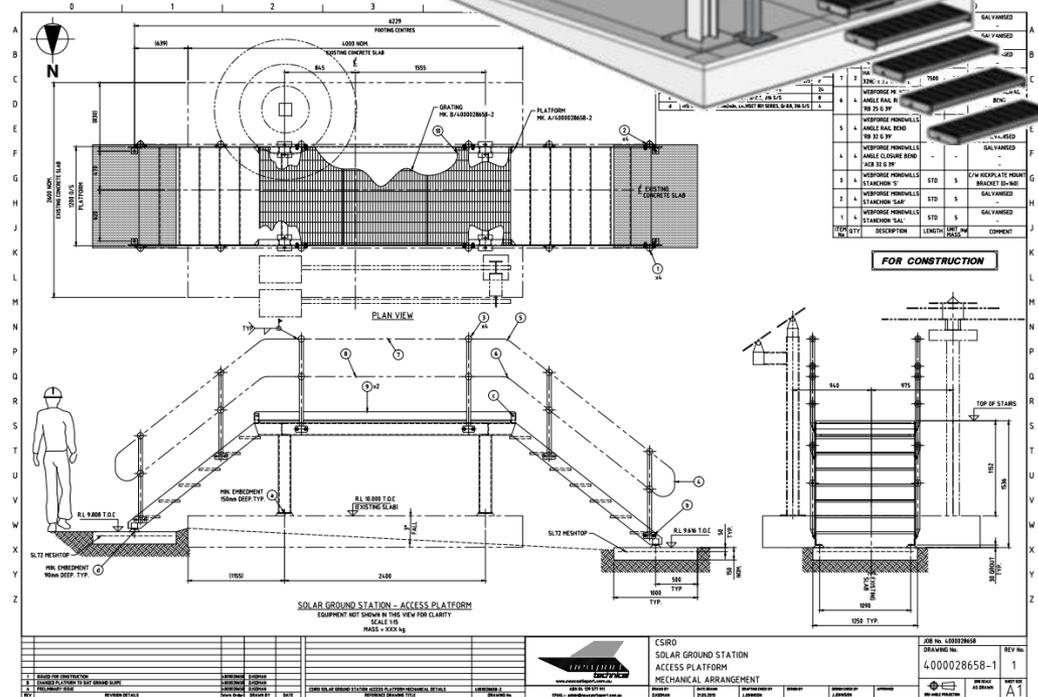
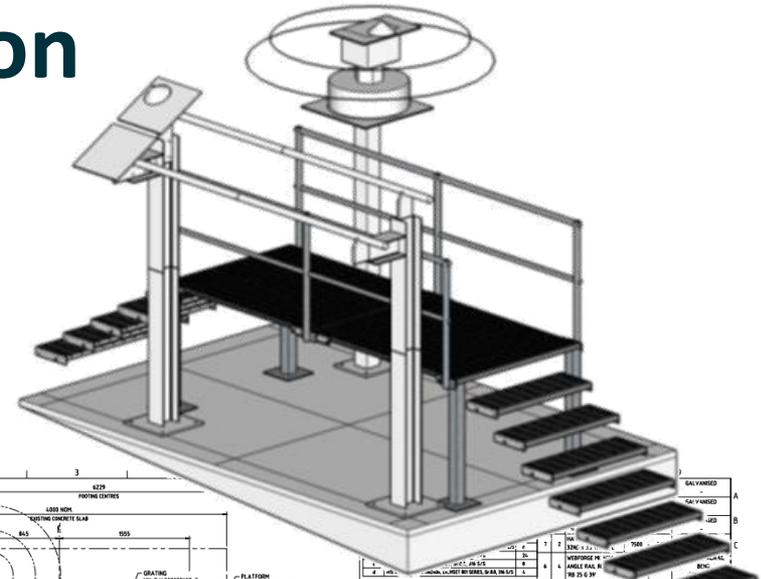
History of the site

- **2005** Monitoring of solar resource
 - Primarily used in concentrating solar thermal work (CST)
 - Measurement of DNI, GHI, and DHI
- **2011** Commissioned and acquired a new monitoring station
 - Interested in photovoltaic module (PV) performance.
 - Included skycam, spectroradiometer and weather station
- **2013** Completed construction on new permanent installation.
 - Initiated program of constant data acquisition
 - Extension of spectral measurement range
- Program of steadily increasing capability.
 - Additional skycam measurement
 - Pyrgeometer measurements
 - Redundancy of existing solar measurements



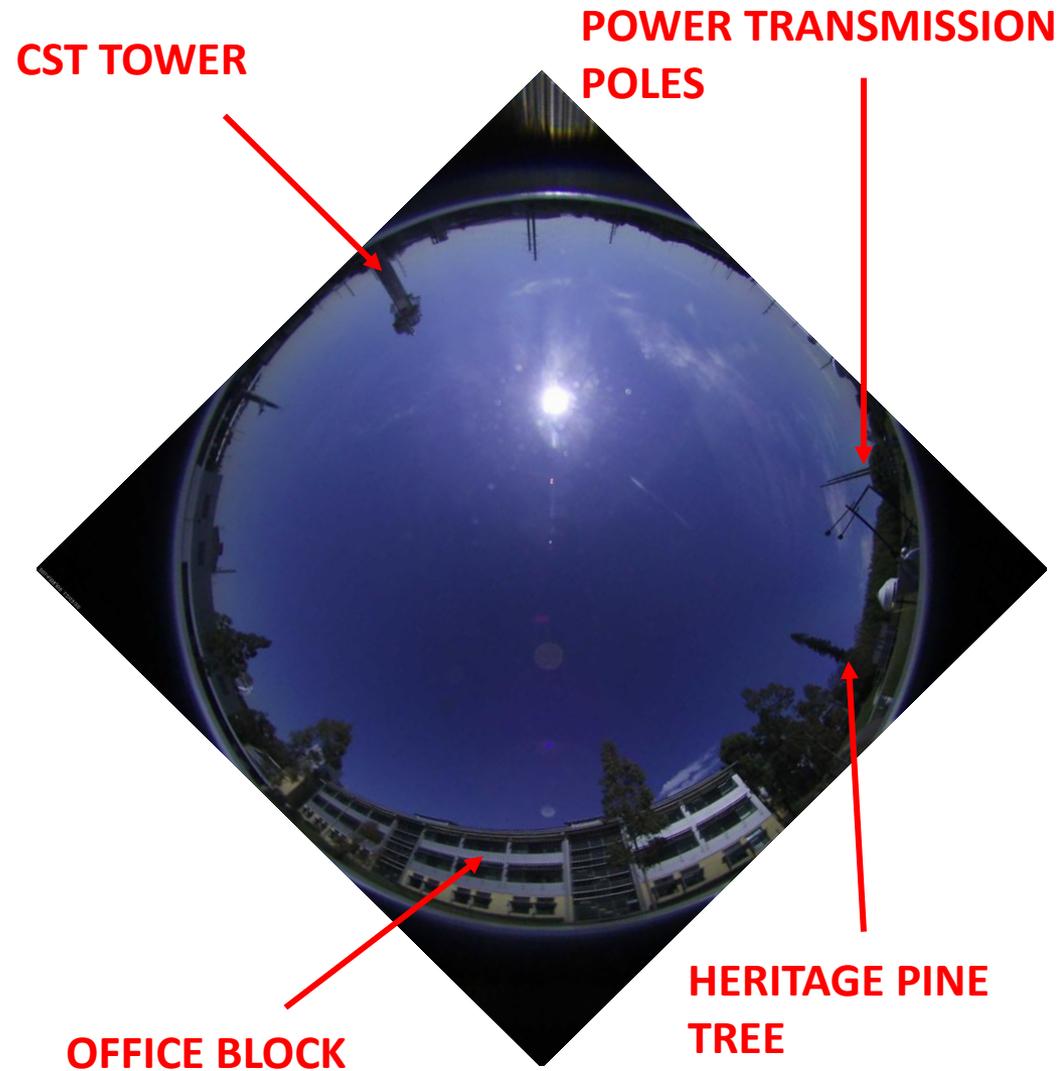
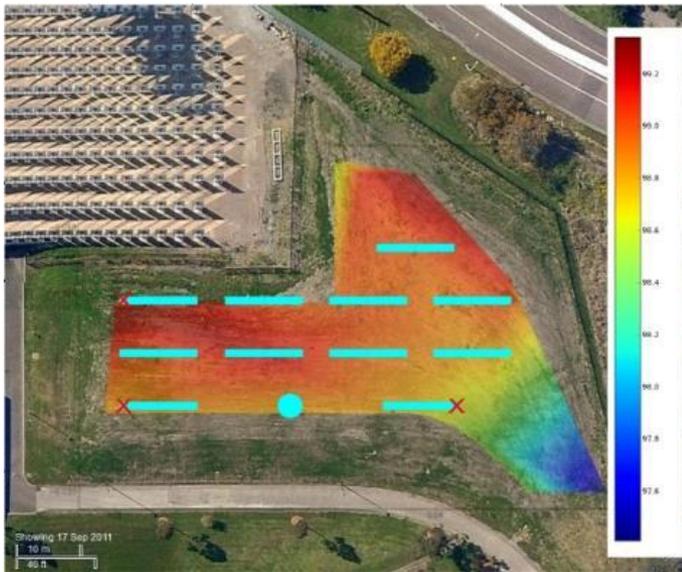
Ground station construction

- Designed an elevated platform for instrument mounting and access
- Position and heights chosen to minimise shading



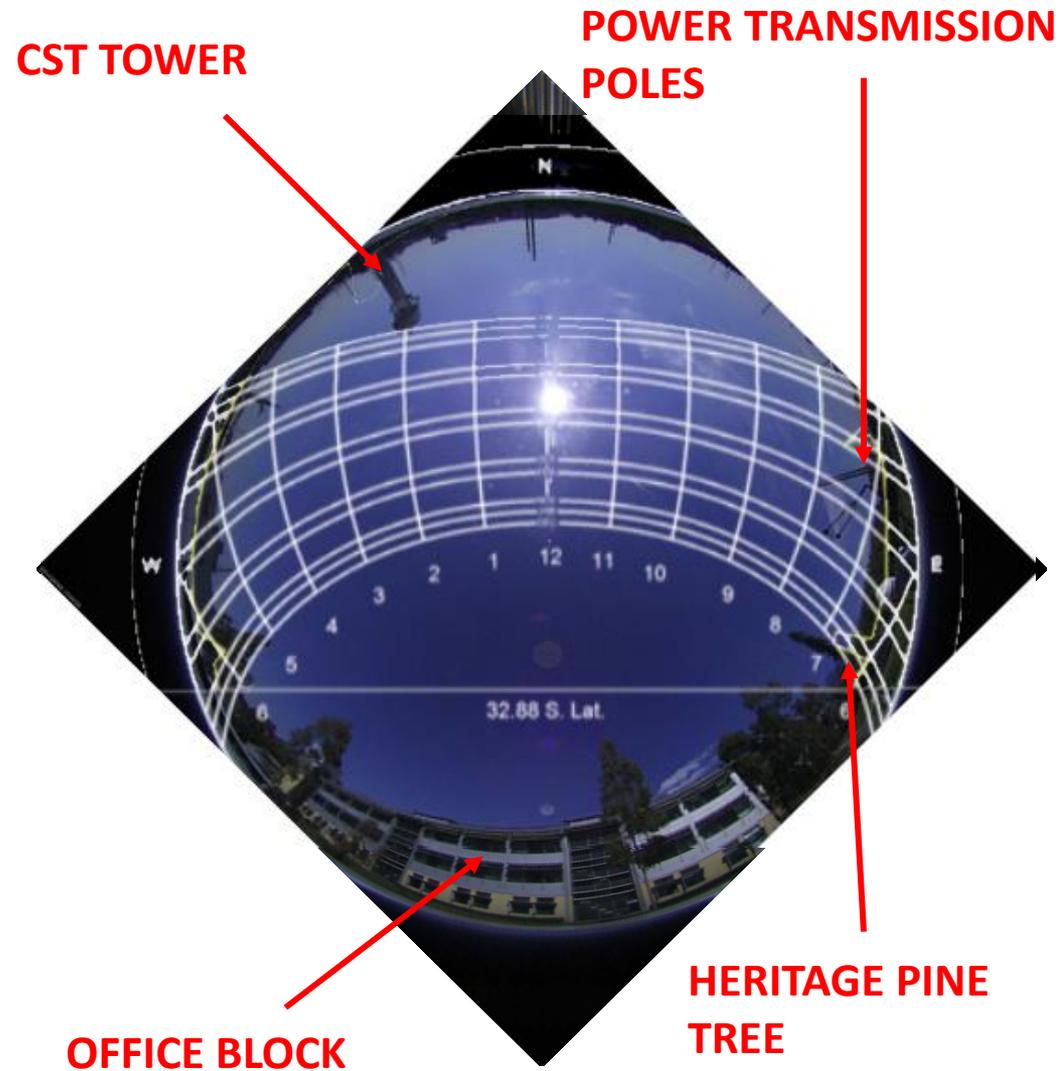
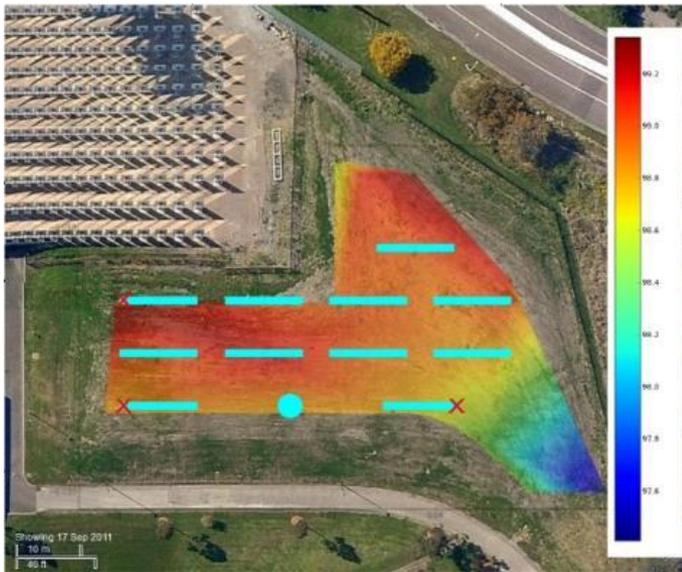
Installation details

- Latitude: -32.8916
- Longitude: 151.7287
- Elevation : 16.5 m
- Instrument height : 2 m

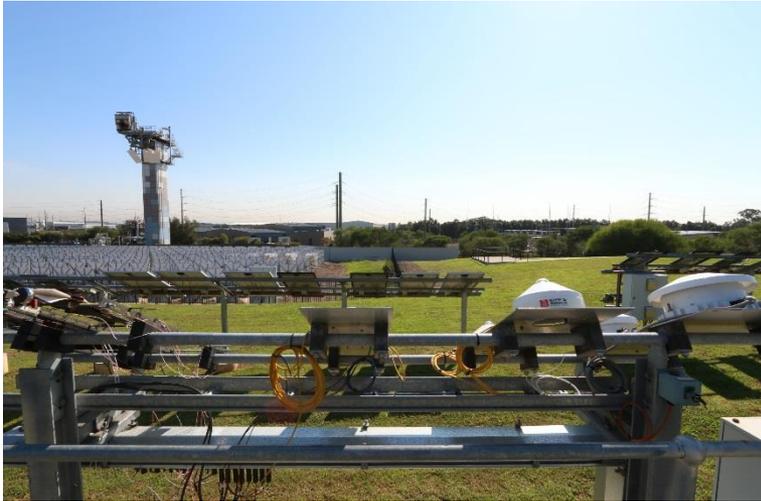


Installation details

- Latitude: -32.8916
- Longitude: 151.7287
- Elevation : 16.5 m
- Instrument height : 2 m



Ground station views



NORTH



SOUTH



EAST



WEST

Geographical details of the site I

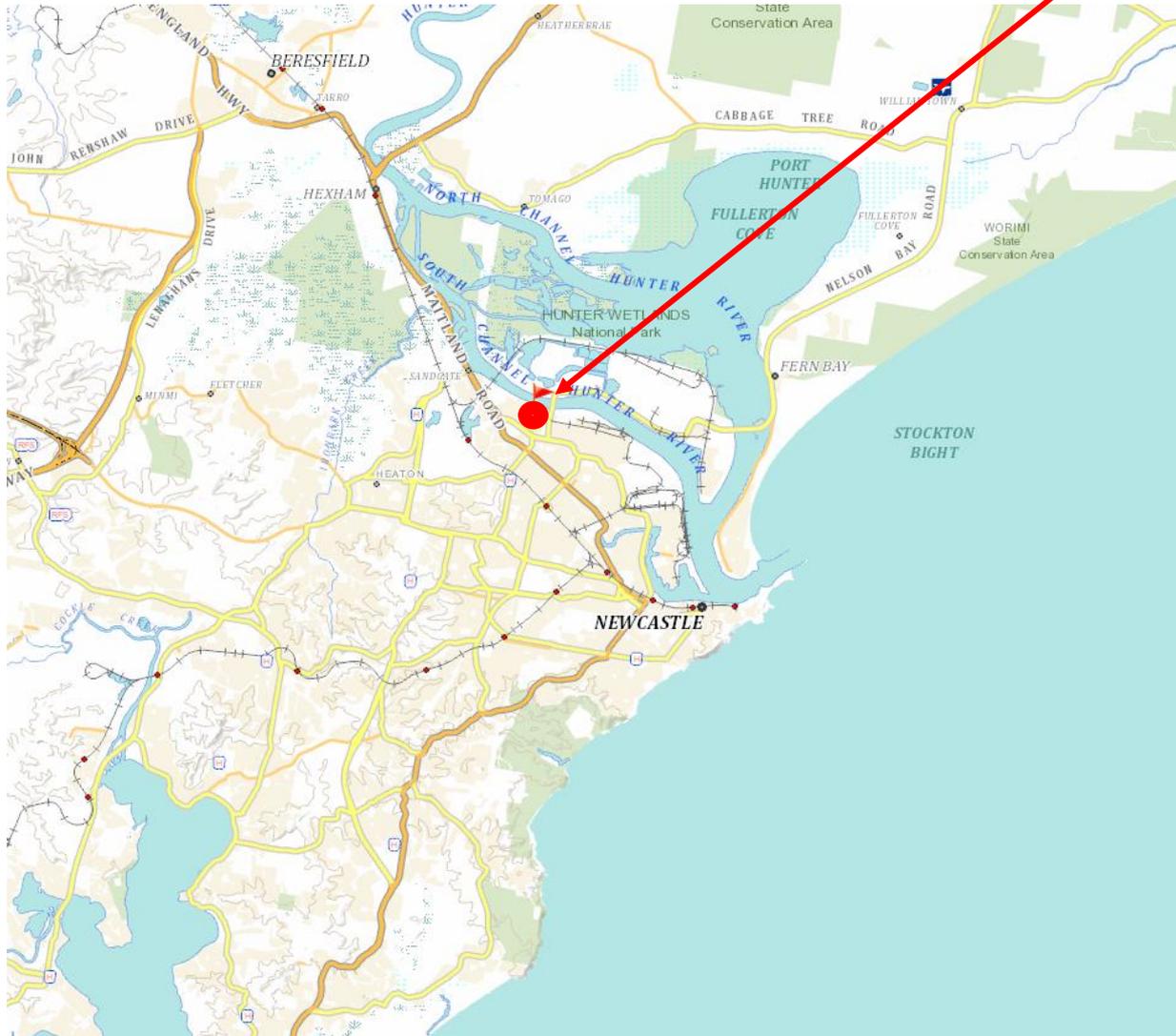


Geographical details of the site II

GROUND STATION

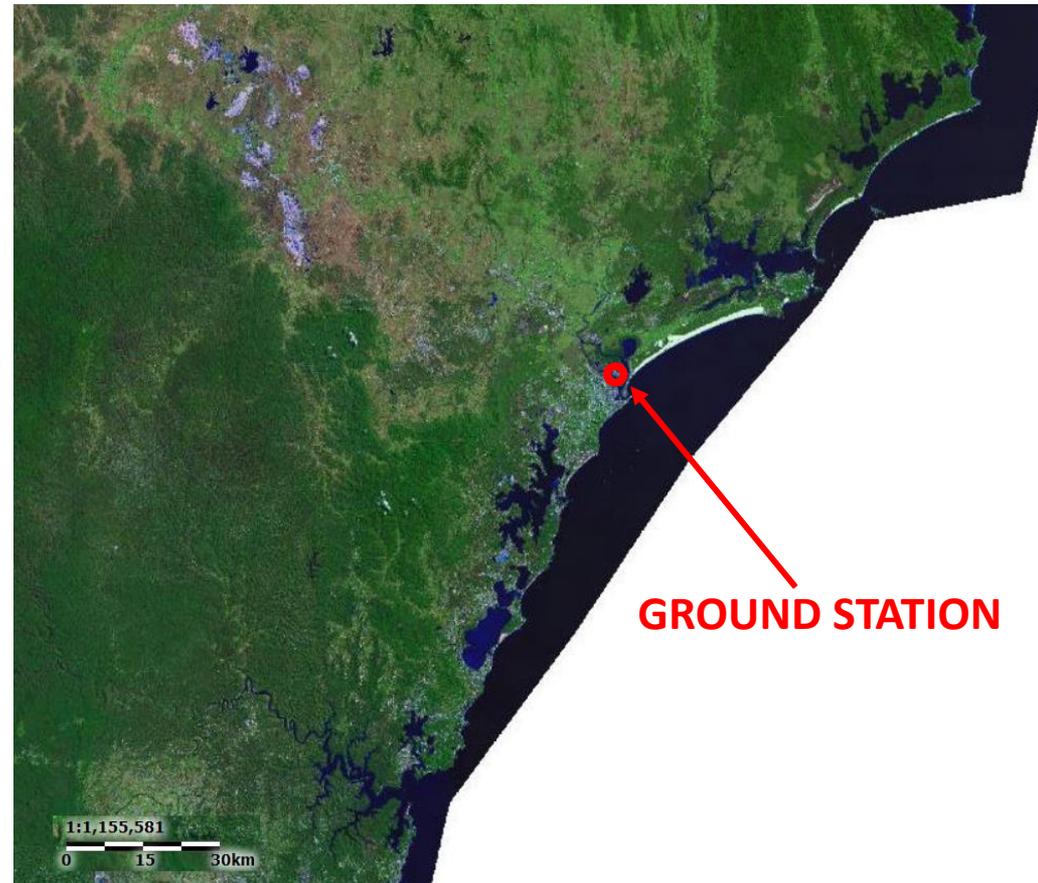


Geographical details of the site III **GROUND STATION**



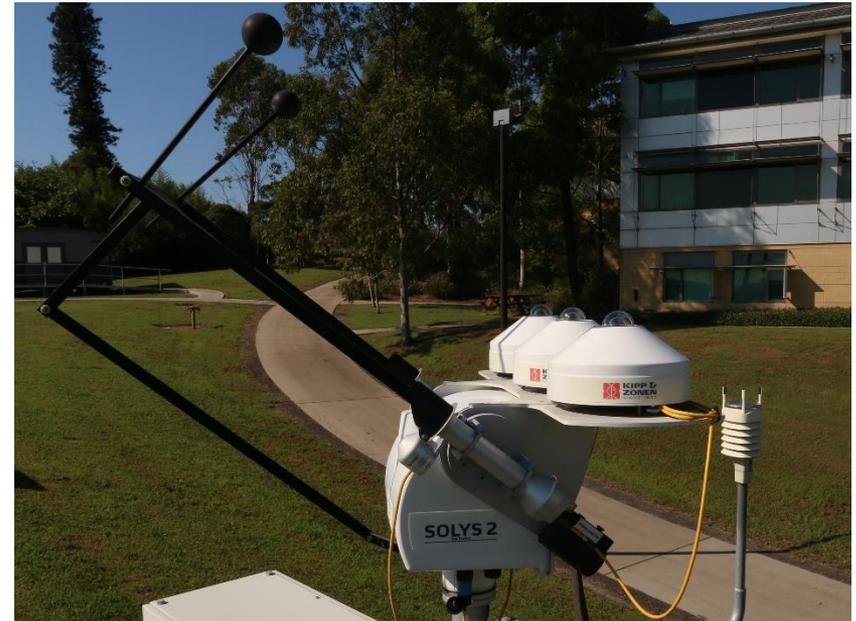
Geographical details of the site IV

- Humid, coastal climate.
- Newcastle climate is a typical coastal climate representative of the Australian Eastern Coast.
- Characterised by mean annual temperatures of 20.5 °C with the mean January temperature of 23 °C and a mean winter temperature of 11 °C. Average annual rainfall is 1103 mm



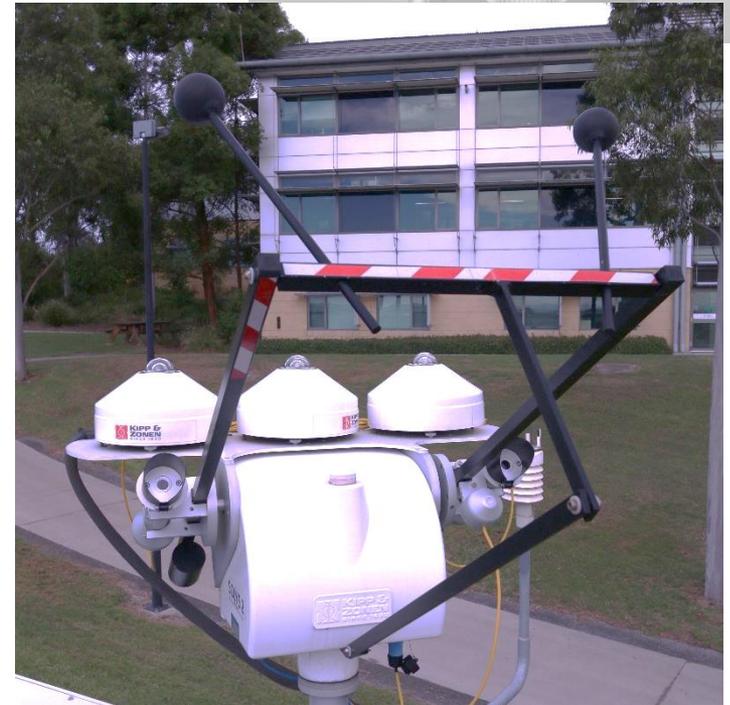
DNI measurement

- 2 x Pyrheliometers (Kipp and Zonen CHP 1)
 - Uncertainty = $\pm 1.1\%$
- Mounted on SOLYS 2 Suntracker equipped with tracker 'eye'
 - Accuracy
 - Passive = 0.1°
 - Active = 0.05°
- Measurement interval = 1s
 - DNI (W/m²)
 - Sensor temperature ($^\circ\text{C}$)



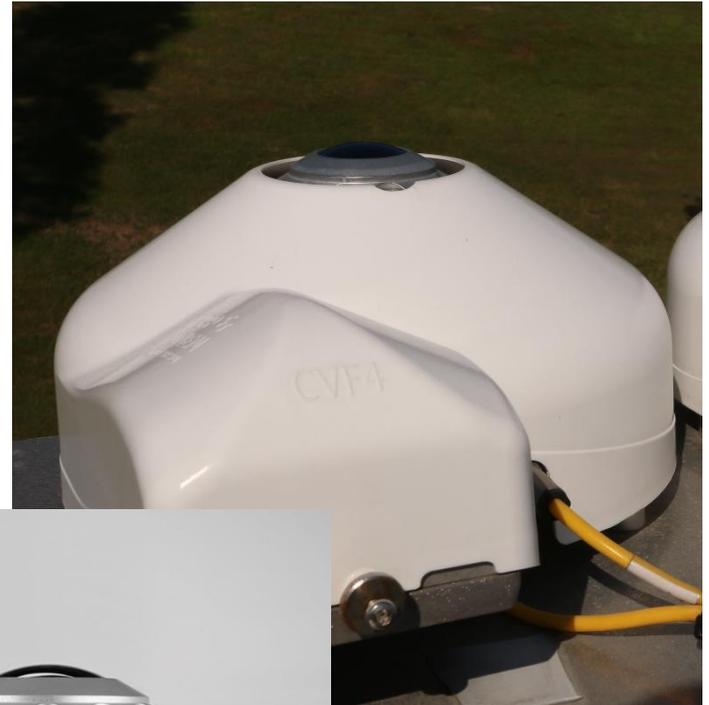
DHI and GHI measurement

- 5 x Pyranometers (Kipp and Zonen CMP 21)
 - Ventilated (3xCVF 3 , 2xCVF4)
 - Uncertainty = $\pm 1.4 \%$
- DHI measurement uses ball shading arms on SOLYS 2 Suntracker.
- Measurement interval = 1s
 - GHI & DHI (W/m²)
 - Sensor temperature (°C)
 - Ventilator Rotation Speed (rpm)



LW downwelling measurement

- 2 x Pyrgometers (Kipp and Zonen CGR 4)
 - Ventilated CVF 4
 - Uncertainty = $\pm 3\%$
- Measurement interval = 1s
 - LW (W/m^2)
 - Sensor temperature ($^{\circ}\text{C}$)
 - Ventilator rotation speed (rpm)

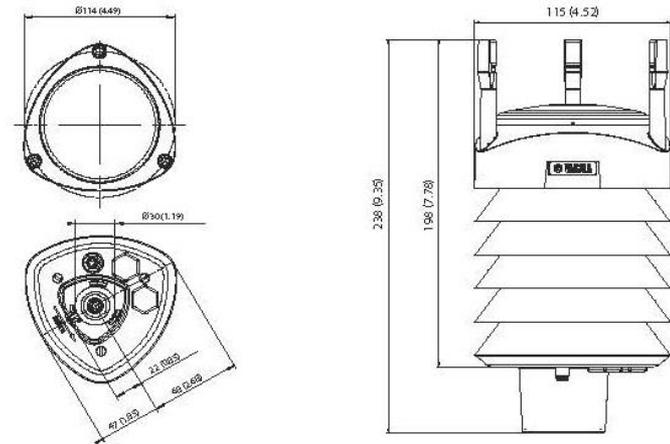


Meteorological measurements

- Vaisala WXT520
 - Mounted at height of 2m above ground
- Compliance with
 - EMC standard EN61326-1; Industrial Environment
 - IEC standards IEC 60945/61000-4-2 .. 61000-4-6 compliant
- Ambient temperature
- Wind speed
- Wind direction
- Relative humidity
- Barometric pressure
- Rainfall
- SDI interface

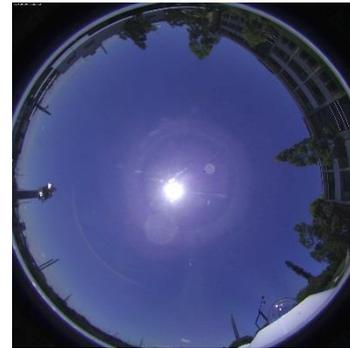
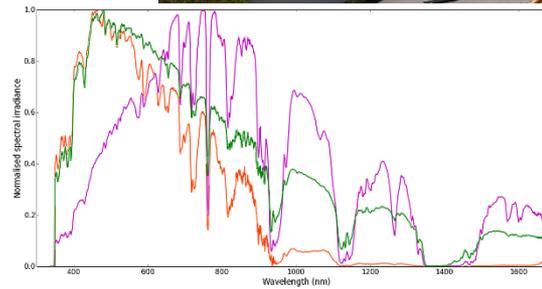
Dimensions

Dimensions in mm (inches)



Other

- GTI (30° tilt)
 - 2 x Pyranometer (Kipp and Zonen CMP 21 with CVF 3 ventilators)
- Spectrum (30° tilt)
 - EKO 710 and EKO 712 paired.
 - 350 – 1700 nm
 - 5 min interval (up to 30s capture time)
- Skycam
 - Vivotek FE8172V sky camera
 - 360° surround view
 - Shutter time 1/5 sec to 1/32,000 sec
 - One horizontal, one 30° tilt
- Silicon reference
 - 30° tilt



Data collection

- Pyranometer, pyrhelimeter and pyrgeometer thermopile signal measured using National Instruments 9214 isothermal thermocouple input module
 - Pyrgeometer error $\pm 3 \text{ Wm}^{-2}$
 - Pyranometer error $\pm 2 \text{ Wm}^{-2}$
 - Pyrhelimeter error $\pm 2 \text{ Wm}^{-2}$
- All other instrument data retrieved via serial communication protocols
- Automated data collection software continuously records to MySQL database.
- Daily data backup conducted.
- Pseudo real time data available for inspection





PV Outdoor Research Facility

Solar Ground Station: Live Data Viewer

Pyranometers

10:27:22

Name	Irradiance (W/m ²)	Temperature (°C)	Ventilator (rev/min)	Fan?	Heat?
Pyro 1 DHI 1	121.7	24.8	2560	<input checked="" type="radio"/>	<input checked="" type="radio"/>
Pyro 2 GHI	724	26.5	2542	<input checked="" type="radio"/>	<input checked="" type="radio"/>
Pyro 3 DHI 2	125.2	25.9	2527	<input checked="" type="radio"/>	<input checked="" type="radio"/>
Pyro 4 GTI 1	951.6	27.9	2540	<input checked="" type="radio"/>	<input checked="" type="radio"/>
Pyro 5 GTI 2	954.1	27	2527	<input checked="" type="radio"/>	<input checked="" type="radio"/>
Pyro 6 GTI 3	946.2	-25.8	0	<input type="radio"/>	<input type="radio"/>
	0	-25.8	0	<input type="radio"/>	<input type="radio"/>

Pyrheliometer

10:27:22

Irradiance (W/m ²)	Temperature (°C)
870.5	19.6

Instruments Cleaned: 09:54:40 10/04/2015

Cabinet Temperature: 24.4°C

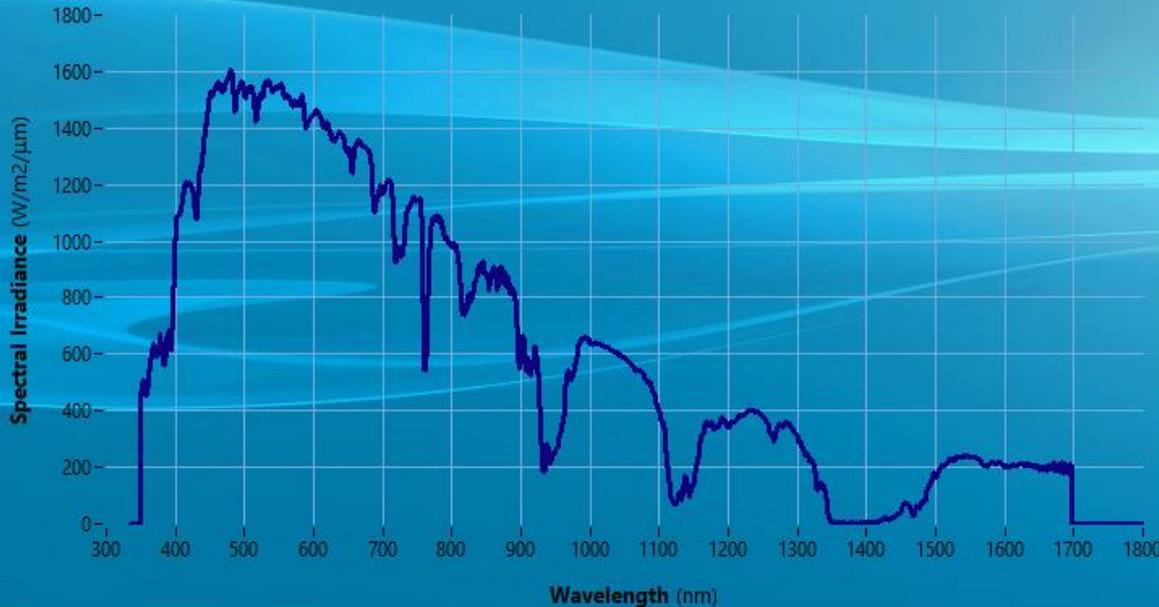
Weather Station

10:27:20

Name	Data
Wind Direction (°)	339
Wind Speed (m/s)	0.5
Temperature (°C)	21.4
Humidity (%)	50.4
Pressure (Pa)	1021.1
Rainfall (mm)	0

Spectroradiometer

10:25:01



Sky Camera

10:25:00



Pyranometer Trend

Pyrheliometer Trend

Temperature Trend

Wind Trend

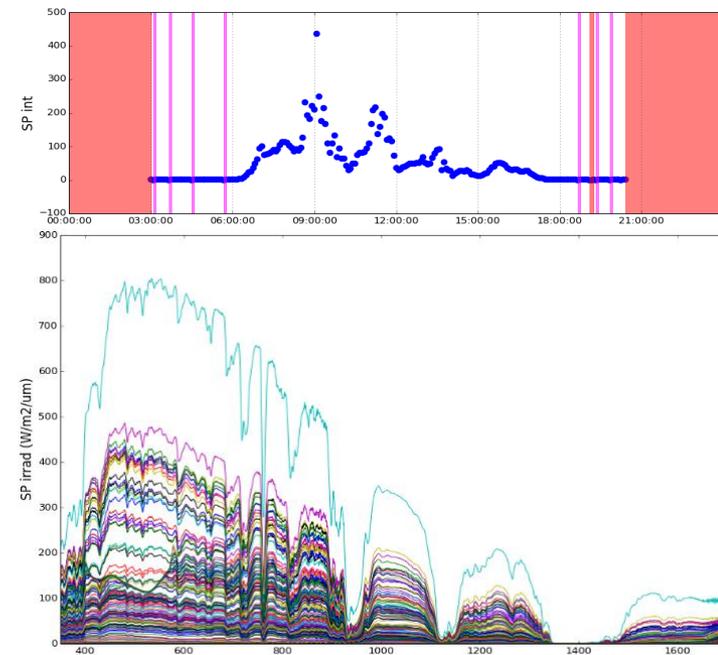
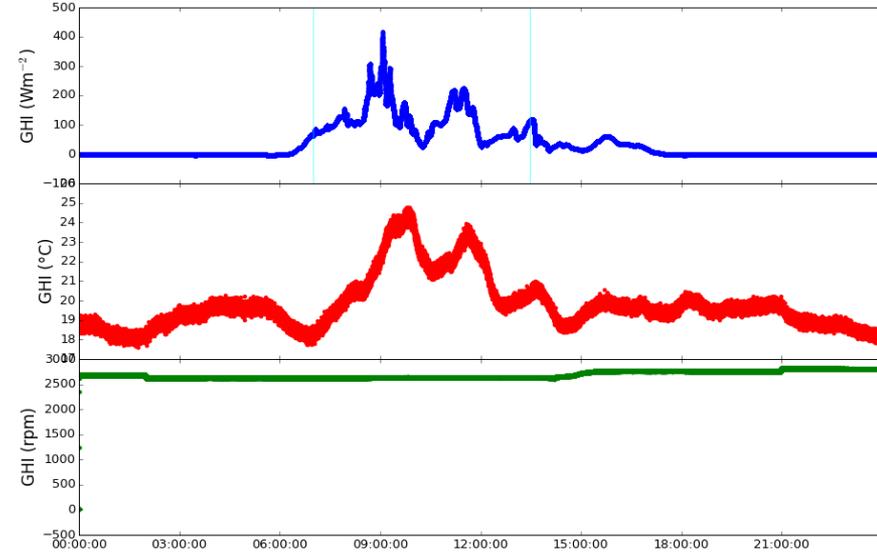
Humidity Trend

Pressure Trend

Rainfall Trend

Data quality checking

- Basic quality checks
 - Data outside expected limits
 - Missing data points
- Known instrument issues
 - Data flagged when signature responses are observed indicating errors
- Cross comparison checks
 - Response from instruments of the same type monitored for variations
 - Transposition models used to check for consistency between instruments
 - e.g. $GHI = DHI + DNI * \cos(AOI)$
 - Relationships between instruments of different types monitored
 - e.g. Integrated spectral irradiance < GTI



Site maintenance

- Email notifications in place for ground station warnings/error notification.
 - Event log maintained for system interruptions
- Weekday maintenance of instruments conducted.
- Instrument calibration is being pursued through BOM
 - Spare pyranometer calibrated and then used to transfer results to other instruments
- Data quality checking
 - Scripts for automated error detection
 - Filtering algorithms developed for PV work
- Backup systems
 - Daily backup of database
 - Redundant pyranometers, pyrhelimeter and pyrgeometer

Summary

- Newcastle site represents Australian coastal climate
- Active research in solar energy technologies means interest in accurate monitoring is maintained
- High quality instrumentation and data acquisition
- Over two years of data currently archived
- Experienced operations team
- Maintenance systems and data quality checking routines in place
- Additional measurements made on site for enriched dataset.

Thank you

Energy

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